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ABSTRACT

An experiment tested the assumption that differences in learning to learn (LTL) are to a large extent explained by differences in what groups of different socioeconomic status (SES) have learned about ways to learn a task. A 6-problem concept attainment task not dependent on verbalization was used. Subjects were 108 elementary school Caucasian children equally divided among 7-, 9-, and 11-year-old age groups, from low and middle SES categories. Certain differences in the shapes of the subjects' learning curves were predicted. However, results failed to confirm that the 9- and 11-year-olds in low SES groups would have increasing gains on the early problems, with decreasing gains on the final problems. The learning curves for the low SES, 7-year-old group and the middle SES, 7-, 9-, and 11-year-old groups were curves of decreasing gains on all problems, as predicted. In summary, the learning curves on Problems 1 through 6 were curves of decreasing gains for both low and middle SES children at the three ages studied. Suggestions are made for future studies. (Author/NH)

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Technical Report No. 141

LEARNING TO LEARN ON A CONCEPT ATTAINMENT TASK AS A FUNCTION OF AGE AND SOCIOECONOMIC LEVEL

Report from the Project on
Situational Variables and Efficiency of
Concept Learning

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This technical report is from the Situational Variables and Efficiency of Concept Learning Project in Program 1. General objectives of the Program are to generate new knowledge about concept learning and cognitive skills, to synthesize existing knowledge, and develop educational materials suggested by the prior activities. Contributing to these Program objectives, the Concept Learning Project has the following five objectives: to identify the conditions that facilitate concept learning in the school setting and to describe their management, to develop and validate a scheme for evaluating the student's level of concept understanding, to develop and validate a model of cognitive processes in concept learning, to generate knowledge concerning the semantic components of concept learning, and to identify conditions associated with motivation for school learning and to describe their management.

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I

INTRODUCTION

Learning to learn (LTL) and the formation of learning sets (LS) are part of the more general topic of transfer of training. Both refer to the fact that when subjects learn successive samples of material of the same kind, there is a gradual improvement in their performance.

There is no consensus on what produces LTL or LS. Harlow (1959) assumes that the process of acquiring a learning set is essentially a matter of eliminating or suppressing response tendencies that lead to errors. Learning set formation is not, in Harlow's view, a process of building response strength for a correct choice; it is basically a process of reducing the strength of incorrect ones.

Postman and Schwartz (1964) subscribe to the view that LTL implies "the acquisition of instrumental habits which facilitate the mastery of new tasks, e.g., the development of successful techniques of mediation" (p. 37).

DiVesta and Walls (1968) and Underwood (1966) do not make statements about what produces LTL, but the definitions they give have implicit in them, a point of view which is similar to that of Postman and Schwartz (1964). DiVesta and Walls (1968) state that LTL simply means "that when individuals learn they learn not only the specific

concept, skill or discrimination demanded by the situation but they also learn something about how to form a concept, to develop a skill, to make precise discriminations, or to solve problems" (p. 191). This definition, with its assumptions, adequately represents the view of LTL taken in the present study.

Non-specific positive transfer on a series of similar tasks has been observed for many types of learning material (McGeoch & Irion, 1952), but it has been most extensively studied in humans in relation to verbal learning (e.g., paired-associate (PA) or serial lists) and discrimination learning. These two categories of learning are the sources of the two terms for the phenomenon. Learning to learn is usually used in connection with verbal learning tasks. The formation of learning sets is usually used to describe improvement in performance on discrimination problems. Improvement in performance over successive discrimination problems was first studied in detail by Harlow (1949), and it was he who labeled it the formation of learning sets.

While many researchers have commented on the importance of LTL or LS for adaptive living (Harlow, 1949) and for the educational process (Harlow, 1949; Katz, 1967; DiVesta & Walls, 1968), Harlow (1959) has made the strongest statement for the theoretical importance of LS or LTL. Not only does LTL or LS represent an important developmental phenomenon in humans and other primates, but it has broader phylogenetic significance. Interproblem learning, Harlow (1959) maintains, "is dependent upon some capacity factor or factors transcending those needed for intraproblem learning of equivalent problems" (p. 504).

Goulet (1968) has also suggested that LTL is an important developmental phenomenon that should be studied in children, although he has provided no statement on LTL's practical or theoretical significance.

The LTL framework, apart from the importance of the phenomenon itself, is seen as a useful one within which to study learning behaviors on many types of tasks. As Harlow (1949) has pointed out "[the] behavior of the human being is not to be understood in terms of the result of single learning situations but rather in terms of the changes which are affected through multiple, though comparable, learning problems" (p. 51).

Jensen (1967) also observed the between-subjects variance (individual differences) that he found in the first half-hour of a learning task reflected little of the underlying factors or basic processes manifested in subsequent laboratory performance. "[Whatever] the subject [did] in his first experience in the laboratory, regardless of the task, [correlated] with little else he ever did . . . in later sessions" (p. 130). Thus, Jensen found that repeated measurements on a single S with comparable tasks were crucial to the task of identifying true individual differences in learning.

Similarly it is suggested that identifying true population differences, such as between socioeconomic status (SES) groups, in learning requires more than a single learning situation. The assumption is that these population differences are to a large extent explained by differences in how much the two groups have learned about how to go about learning a task. And, in addition, it is assumed that LTL in the laboratory would

supplement or speed up the acquisition of the relevant developmental experiences needed, particularly by the low SES Ss, for a given task.

These ideas about the importance of LTL for evaluating SES differences are implications drawn from descriptions of the nature of the LTL process. Deese and Hulse (1967) provided the description from which these implications were drawn. They observed that one of the things that LTL does is to reduce between-S differences in performance. Further, they commented that how people perform on tasks is in part explained by how much they have learned about how to go about learning those tasks, and they concluded, "when people have had an equivalent amount of experience at learning tasks of a given type, they are more likely to be more homogeneous in their performance on learning a new task of that type" (p. 365).

Data reported by Duncan (1960) further supported the notion that there might be an interesting relationship between SES and LTL and suggested a form that this relationship might take. Duncan analyzed the performance of upper and lower quartile learners on a non-verbal paired-associate (PA) task. On the first of ten tasks the learning curve of the fast learners was negatively accelerated; most of the improvement for these learners came in the first few trials. The learning curve for the slow learners was positively accelerated, i.e., their gains increased over trials. On the tenth task, however, the learning curves of both groups were negatively accelerated, and furthermore, the differences between the two groups were slight. The learning curves for the two groups on tasks one and ten are shown in Figure 1.

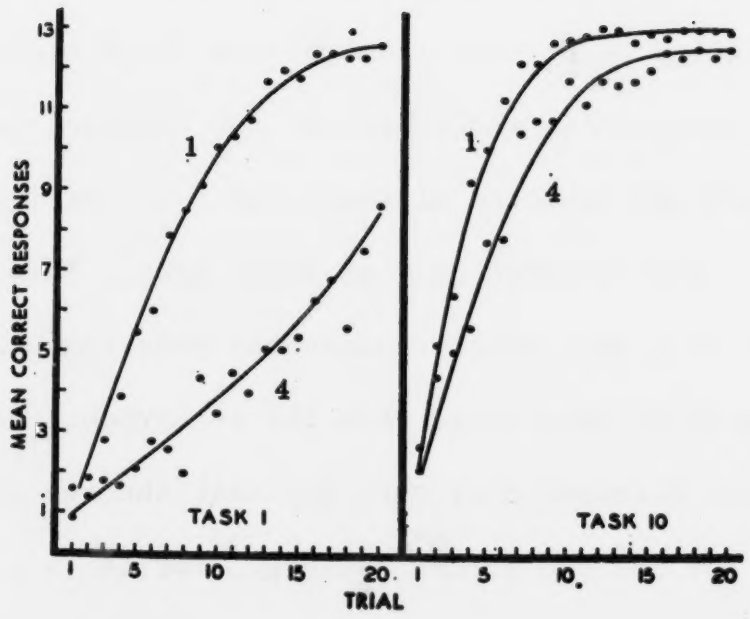

Fig. 1. Performance on Tasks 1 and 10 of the Ss in the top and bottom quartiles on Task 1. 1 = Top quartile of Ss; 4 = Bottom quartile (Duncan, 1960, p. 113). Reproduced by permission of The American Journal of Psychology, copyrighted by the Editor, 1960.

The current study was planned to investigate LTL or LS in relation to age in children (7, 9, and 11 years) and SES membership (low and middle). The learning task chosen was a concept attainment task which also met the requirements for a learning set procedure. There were six problems with 60 discrimination item pairs per problem. This task was chosen primarily because most of the studies of LS or LTL in children involve relatively simple discrimination or oddity problems; none are known which investigate LS or LTL on more complex problems.

The expectation was that the performance of the middle and low SES groups would parallel those of the upper and lower quartiles in Duncan's (1960) study, i.e., the middle SES children would exhibit decreasing gains over items on early problems, while the low SES children would

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exhibit increasing gains over items on early problems, but that both would show decreasing gains over items on the final problem or problems. However, this difference in the shapes of the learning curves for the two SES groups was not expected at every age. Increasing gains were predicted for low SES children only at older ages. This restriction had its basis in the fact that other researchers studying SES differences on various learning tasks have found that the performance differences between SES groups decrease over age, but that the age at which the performance scores for the two groups converge, varies as a function of task difficulty. For example, with a PA task, Semler and Iscoe (1953) found that SES and ethnic differences in paired-associate learning ability appeared at ages five and six but decreased thereafter (age 8). Rohwer, Suzuki and Ehri (1968) observed that upper strata children were superior on a paired-associate task only in the kindergarten and grade 1 cases, not in grade 3. Rohwer, Ammon, Suzuki, and Levin (1969) also found that population differences on a paired-associate test were significant only for kindergarten children. Thus, the performance scores of different SES groups on a PA task appear to converge between ages 6 and 8. However, on a more complex task, thought to test the development of problem-solving strategies, Odom (1967) found that performance differences between different SES groups did not converge until age 10.

Since a concept attainment task is generally recognized as being more complex than a PA task and is at least as complex as the task used by Odom (1967), performance scores of the two SES groups on a concept attainment task would not be expected to begin to converge before age 10 or 11.

The underlying assumption is that true differences between low and middle SES groups exist for a concept attainment task at younger ages, for example 7 and 9 years, but that these differences disappear by age 11. This amounts to postulating a developmental lag in concept attainment abilities for the low SES children at ages 7 and 9 which is then made up by age 11.

The learning curves for the six SES by age groups for Problems 1-6 were expected to take the form of the curves shown in Figure 2.

An examination of these curves reveals that the learning curves for Group 1, the low SES, 7-year-old group, show a slight increase in mean number correct over Items for Problems 1 and 6, although, the curves are primarily flat. There is an increase in mean number correct for each Item from Problem 1 to 6, but this increase is smaller than the increase for any of the other five groups. And, the final asymptote is lower for this group than for Group 4, the middle SES, 7-year-old group, indicating true population differences at age 7.

The learning curve for Group 2, the low SES, 9-year-old group, is slightly positively accelerated for Problem 1, but negatively accelerated on Problem 6. It is assumed that a hint of the change in the shape of the learning curves across Problems predicted for the 11-year-old group is present at 9 years. Again, the asymptote on Problem 6 for Group 2 is lower than the asymptote for the middle SES group at the same age, indicating true population differences at this age.

For Group 3, the low SES, 11-year-old group, the learning curve for Problem 1 is clearly one of increasing gains. The learning curve on

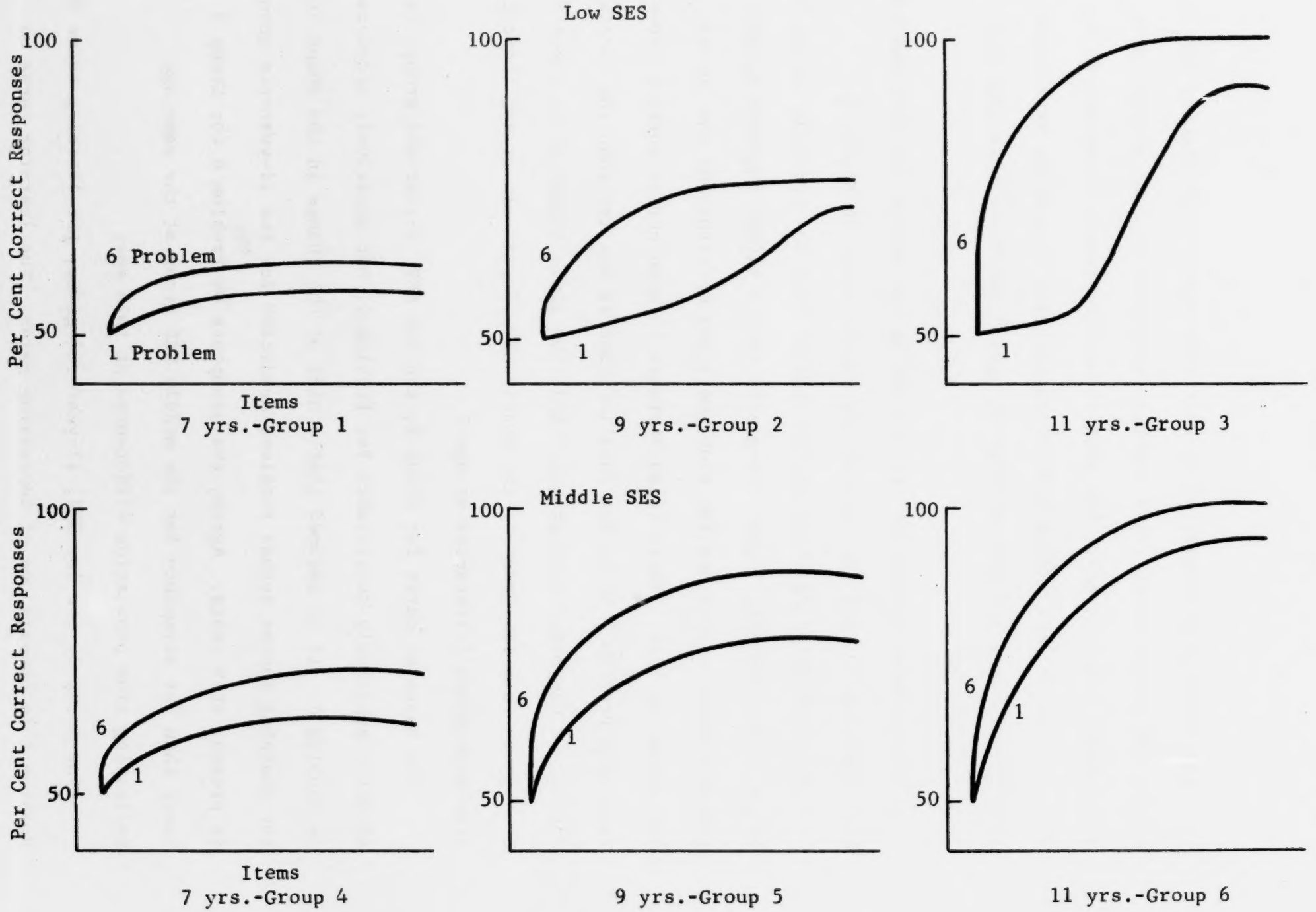

Fig. 2. Hypothetical Learning Curves over Items for Problems 1 through 6 for the 6 S Groups.

Problem 6 for this group is one of decreasing gains, and the asymptote on Problem 6 is not different from the Problem 6 asymptote for the middle SES group at age 11. The differences between the two SES groups at this age are thus seen as relatively small differences in amounts of experience with learning how to learn that can be compensated for during a brief period in the laboratory.

For the three middle SES groups, the learning curves on Problems 1 and 6 are curves of decreasing gains, although for the 7-year-old group, the curves are primarily flat.

In summary, the shapes of the hypothetical learning curves do not change over Problems for Groups k, 4, 5, and 6. The shapes of the curves from Problem 1 through 6 change slightly for Group 2, but most dramatically for Group 3.

The predictions outlined above represent a detailed description of a theory that relates LTL on a concept attainment task to age and SES membership. Following the suggestion of Walster (1970), statistical tests were conducted for this theoretical statement, and only this statement.

II

RELATED LITERATURE

One of the first to report learning to learn effects was Ward (1937). Although incidental to the purpose of his experiment, Ward's results showed that the number of trials to criterion on a given list of nonsense syllables decreased as a negatively accelerated function of practice over 16 lists.

Meyer and Miles (1953) conducted one of the first analytic studies of the effects of successive transfer. College students learned a series of 20 nonsense syllable lists; one list was given per day for a total of 5 trials per list. The mean number of syllables recalled in all 5 trials was about 24 on List 1, but by List 20 had increased to almost 35.

More recently Duncan (1960) reported learning to learn over ten non-verbal paired-associate tasks of the same type with college students. The mean performance over 20 trials for all 10 tasks was typical in that it revealed an increasing skill in total performance but decreasing gains over tasks, i.e., it was negatively accelerated.

Studies of variables which affect learning to learn have begun to appear recently. Postman (1968) found that learning to learn was specific to the paradigm used with a three-stage mediation task.

Monge (1968) investigated the effects of pacing on verbal learning set formation.

Little is known about the development of learning to learn on verbal learning tasks in children (Keppel, 1964; Goulet, 1968). In one of the rare studies in the area, Rohwer (1969) reported learning to learn over paired-associate lists for low SES Negro children (kindergarten, first, and third grades), but not for white children.

In contrast, the data on learning sets with discrimination tasks in humans has produced many studies with children, both normal and mentally defective.

Kuenne's study, reported by Harlow (1949), was the first to demonstrate learning set formation on a discrimination learning task with children. Kuenne's subjects ranged in age from 2 to 5 years.

Shepard (1957) investigated the learning set phenomenon in pre-school children (4 to 6 years) with a conditional space discrimination task (e.g., if A, then left block; if B, then right block). The results revealed a marked improvement from the first to the second task, but then a slight decline over the remaining four tasks, which Shepard attributed to boredom.

Other studies of the formation of learning sets in children have examined learning sets on particular types of problems, such as oddity problems (Saravo & Gollin, 1969); the effect of different types of problems (object discrimination, oddity, oddity-nonoddity), on learning sets (Ahlers, 1968); and the effects of task difficulty and sequencing (Katz, 1967; Bowers, 1963).

Crooks (1967) examined the influence of overtraining on learning set formation. She found that overtraining facilitated transfer from problem to problem in an experiment when the subject learned a categorization rule which applied to the solution of subsequent problems in the series.

Harter (1965) and Koch and Meyer (1959) have explored the relationship of mental age (MA) to learning set formation. Koch and Meyer (1959) found that rate of learning, i.e., days to criterion was negatively related to MA in their Ss ($r = -.59$). Harter (1965) reported that both IQ and MA affect learning set formation. Several studies (Ellis, Girardeau & Pryer, 1962; Girardeau, 1959; Kaufman & Peters, 1958; Stevenson & Swartz, 1958; Wischner & O'Donnel, 1962) have compared normal and mentally defective children on learning set formation.

Levinson and Reese (1967) carried out the most extensive investigation of LS formation on a discrimination learning task with humans. Their Ss included nursery school children, fifth graders, college students, and representatives of an aged population. They found that the general shape of the acquisition curve was essentially the same at the four ages sampled. However, there appeared to be differences in the systematic response patterns used by Ss in the four age groups.

All of the studies reported above on learning set formation in children involved relatively simple object-quality discrimination or oddity problems.

With adults, however, learning set formation has been investigated on more complex learning tasks.

Adams (1954) investigated learning set phenomena on a fairly complex task in which adult males had to learn to associate each of four buttons with a different spatial arrangement of stimuli. Adams (1954) was also interested in the efficacy of multiple versus single problem learning, as were Callatine and Warren (1955).

Adams (1954) found that the group receiving training on the single problem was generally superior to the multiple problem group. Callantine and Warren (1955), using a relatively simple concept learning procedure, found that the Ss given a large number of examples per concept on the training task were markedly superior on a transfer task. Callantine and Warren (1955) attributed their apparently contradictory results with Adams (1954) to differences in procedures and tasks.

Weber and Woodward (1966) observed learning to learn phenomena in the processing of positive and negative information in a concept learning paradigm modified to resemble a standard learning set procedure.

Byers (1963) interpreted an increase in efficiency, both in terms of length of time Ss spent at the task and the number of cards selected, as evidence of learning set on a traditional concept attainment task.

No studies are known which deal with learning to learn on comparable complex learning tasks, such as concept attainment, with children.

III

METHOD

Subjects

The Ss were 108 Caucasian children attending an elementary school in a central Wisconsin community of approximately 18,000 people. They were equally divided among the following age groups: 7, 9, and 11 years, and each S was within six months of the age specified. Each age group was divided into two categories differing in social class membership.

The first socioeconomic strata consisted of children randomly selected from among those whose families had received Title I assistance on the basis of economic criteria alone. To be eligible for such assistance, the families had to have an income of $2,000 or under, as determined by the State Department of Public Instruction.

The second group of children were randomly selected from all those children at the appropriate ages whose families had not received Title I funds for economic reasons.

Stimulus Materials

The stimulus materials were a set of colored line drawings (actually made with rubber stamps which were made from line drawings) of trains. Each train had an engine or locomotive and four other cars, which could be various combinations of four types of cars--coal car,

boxcar, tanker, caboose--that also varied in color--blue, green, red, yellow. The drawings for the locomotive and four types of cars are shown in Figure 3.

The trains were printed on white 8 1/2 x 11 card stock, covered with clear plastic sheets and bound in a loose-leaf binder.

Two trains appeared on each page. One of them represented an example of the concept, and the other did not. The correct concept always involved a car of a certain type and color, i.e., the concept was always a conjunctive one in which color and type were the relevant attributes. The position of the car (first, second, or third, etc. after the locomotive) and the number of cars of one type or color were always irrelevant.

This concept learning paradigm was modeled on the inductive procedure used by Osler and Fivel (1961). In their experiment, the S was presented with a series of pairs of items, one of which was an exemplar or the concept and one of which was not. The S then chose the item that he thought was positive.

The advantages of this type of concept attainment procedure are that a correct response does not depend on verbalization, and, with certain types of concept items, it allows for a large but constant number of trials on a single problem.

While the concept attainment procedures to be used here are similar to those of Osler and Fivel (1961), the particular concepts to be used are different. Osler and Fivel (1961) used the concepts bird, animal, or living thing. Concepts of this sort are difficult to classify in terms of relevant and irrelevant attributes or the rule

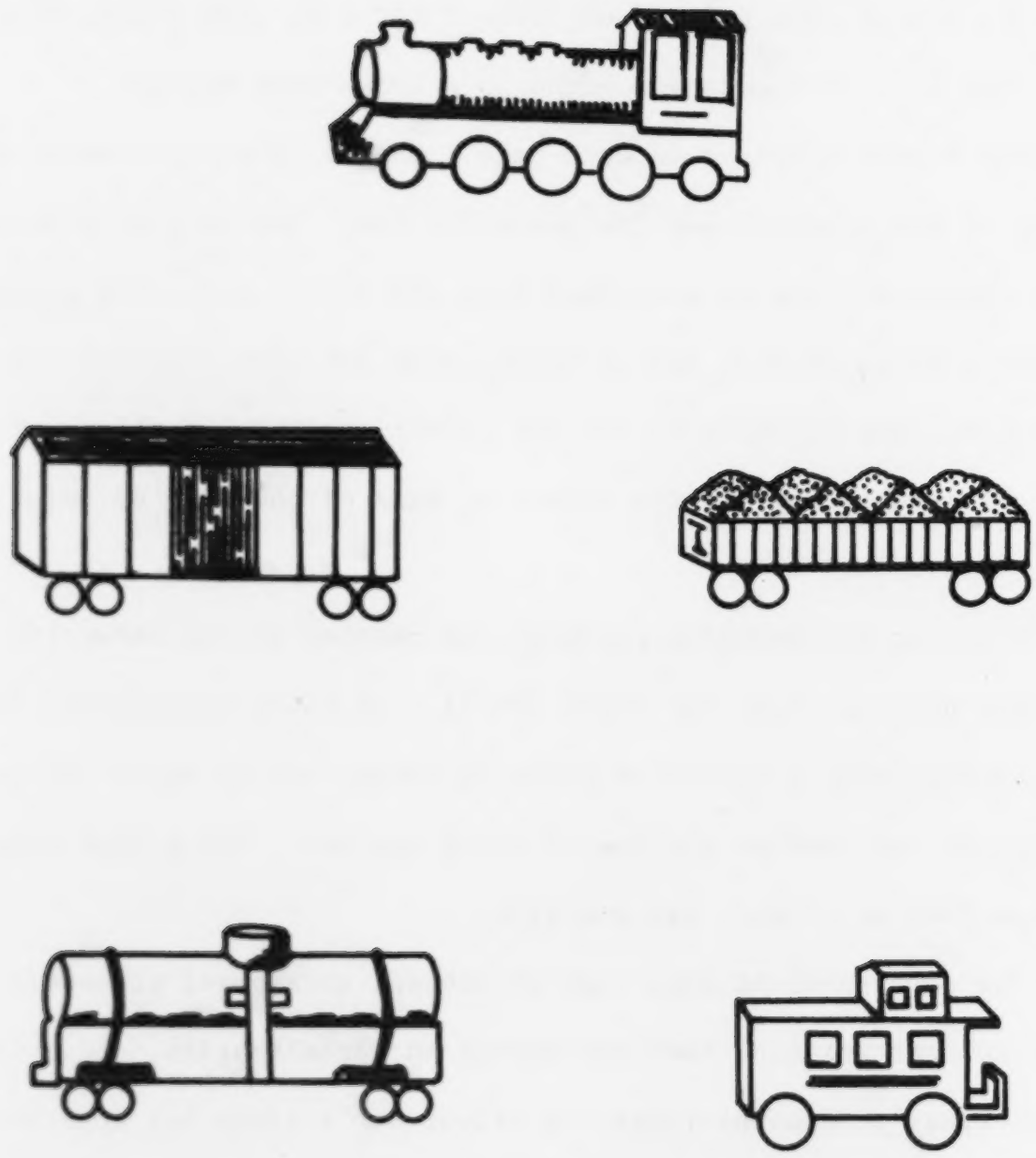

Fig. 3. Stimulus Items for Concept Attainment Task--Locomotive, Boxcar, Coal Car, Tanker, Caboose.

for combining them. It was decided to use here stimuli that could be classified in terms of attributes and combinational rules, in order to place the task in the same context as the more traditional concept learning studies.

The primary disadvantage of the induction procedure is that it does not allow the examination of information-seeking strategies used by the subjects. Since strategies were not of special interest here, this disadvantage was not seen as prohibitive.

On the basis of the Byers (1963) study in which it was found that adults form learning sets over six concept attainment problems, six conjunctive concept attainment problems (color and type) were randomly selected from the sixteen possible problems produced by this set of stimuli. The six problem solutions were: (1) yellow tanker, (2) blue boxcar, (3) green coal car, (4) blue caboose, (5) yellow boxcar, (6) red tanker.

For each of the six problems there were 60 positive-negative pairs of items. The number 60 was a pragmatic choice. Osler and Fivel (1961) presented a maximum of 150 pairs to their Ss. However, with six problems given in a single session, 150 pairs of items per problem would have made the task too long and tedious for the younger children. Sixty was merely the largest possible number of items per problem that could be reasonably given.

In generating the 60 pairs of items for the first problem, the following procedures were used. First the position of the positive train, i.e., whether it appeared first or second on the page, was

randomized. Then the order of the car that constituted the solution was randomized within the positive train; that is, it was randomly determined whether the "special" car was the first, second, third, or fourth car following the locomotive. The three other cars that completed the positive train were then decided upon in a random manner. The four cars of the non-exemplar or negative train were likewise determined in a random manner, with the restriction, of course, that it could not contain the particular car (color and type) that constituted the solution to the problem.

In this way a single set of 60 positive and negative pairs were constructed, and from these the 60 pairs for the remaining five problems were produced. Using the same sequence of instances to produce all six problems made it possible to control easily the sequential changes in the relevant and irrelevant stimulus dimensions. This is in accordance with the work of Detambel and Stolurow (1956) and Anderson and Gutherie (1966) who demonstrated that the degree of change in the irrelevant as well as the relevant dimensions influences the difficulty of the problem. Although, Peterson (1968) maintains that the degree of change in the irrelevant dimensions does not influence the difficulty of a problem, it was thought wise to control changes in the irrelevant dimensions in the interest of insuring that all of the problems were of equal difficulty.

An example will clarify how this was done. The first set of instances generated was that for "yellow tanker."

	EXEMPLAR (Must contain at least one yellow tanker)				NON-EXEMPLAR (Must not contain a yellow tanker)			
	car 1	car 2	car 3	car 4	car 1	car 2	car 3	car 4
Trial 1	yellow tanker	green boxcar	red coal	blue caboose	blue boxcar	green boxcar	blue coal	blue caboose
Trial 2	green boxcar	green coal	blue tanker	yellow tanker	green caboose	green boxcar	blue tanker	red coal
etc.								

In producing the instances for the next problem, for example, "blue caboose," all yellow cars became blue and vice versa; all red cars became green, and vice versa; all tankers became cabooses, and vice versa, and all boxcars became coal cars and vice versa.

	EXEMPLAR (Must contain at least one blue caboose)				NON-EXEMPLAR (Must not contain a blue caboose)			
	car 1	car 2	car 3	car 4	car 1	car 2	car 3	car 4
Trial 1	blue caboose	red coal	green boxcar	yellow tanker	yellow coal	red coal	yellow boxcar	yellow tanker
Trial 2	red coal	red boxcar	yellow caboose	blue caboose	red tanker	red coal	yellow caboose	green boxcar

The four remaining problems were all generated from the original set of problem instances in a similar manner.

The set of stimulus materials and the concept attainment paradigm used here have two characteristics that bear mentioning.

The first has to do with the fact that both a positive and a negative instance of the same concept are visible simultaneously. Precisely how this influences rate of learning compared to paradigms in which positive and negative instances are shown successively is unclear. However, it does complicate matters tremedously in trying to control stimulus sequencing. This is because one must be concerned with the degree of change between an exemplar and a non-exemplar on a single trial, and, in addition, the relationship of the positive instance in Trial 1 to the positive instance in Trial 2, and possibly even the negative instance in Trial 1 with the negative instance in Trial 2, etc. One realizes the difficulty when one tries to describe the task in terms of the distinctions between constant, mixed, and alternating series made by Anderson and Gutherie (1966). That is, on any single trial, the positive and negative instances constitute a sort of alternating series. Whereas, the positive instances alone on trials 1, 2, 3, etc., constitute a constant series.

The result is that this does not seem to be a very workable task for situations in which precise control over stimulus sequencing is desired. It was a feasible paradigm here because the sequencing of the original problem was generated randomly and then all others modeled on it.

The second characteristic has to do with the nature of the stimulus itself. The stimulus, i.e., the train, appears to be a "distributed" representation like that used by Glanzer, Huttenlocher, and Clark (1963), although, in fact, its solution, which involves only a single car in the

train, makes it a "compact" stimulus. The distributed nature of the stimulus, however, creates two dimensions that are difficult to manipulate--they are position, i.e., whether a particular car is in the first, second, third, or fourth position behind the locomotive; and number of cars of one type or color, i.e., whether there are one, two, or three red cars or one, two, or three coal cars. For example, a conjunctive concept involving color and number, say three red cars, involves three of the four cars that make up the train, whereas a conjunctive concept involving color and type involves only one car in the train.

The difficulty with position as a relevant dimension enters when one tries to control the degree of change in relevant and irrelevant dimensions from trial to trial. It is not possible to make position equivalent to type or color from one set of problem instances to the next, as was done with color and type.

These features of the task, however, were coincidental by-products of two overriding consideration: (1) to have a concept attainment task where a correct response was not dependent on verbalization, (2) to have a concept attainment task that allowed for a large and unique number of positive instances on a single problem.

For other purposes, the task might be modified to conform to Glanzer, Huttenlocher, and Clark's (1963) distributed representation, in which case the troublesome irrelevant dimensions of position and number would disappear.

Or, in order to keep the two features mentioned above (no verbalization, large number of positive instances), but at the same time to make the problem more difficult, other dimensions, such as some sort of insignia on the cars to represent various railroads, etc., might be added.

In addition to the features of the concept attainment task enumerated above, the task used here also meets all the requirements for learning set experiments listed by Kintz, Foster, Hart, O'Malley, Palmer, and Sullivan (1969). It involves "improvement over a series of more than two problems with common solution bases" (p. 190). It requires the simultaneous discrimination between two stimulus objects with a different pair of stimuli for each problem. Metaphorically speaking, it meets the criterion of "blind baiting of the correct stimulus" (p. 190). And, subjects were rewarded for every correct response.

Procedure

Each S was tested individually in a single session. The S and the E were seated at right angles to one another at a low table. In front of the S were an example booklet similar to those actually used in the concept attainment task and a matrix of 16 train cars (four types and four colors).

The S was told that he was going to see some pictures of trains, as in the example booklet. It was explained that every train had an engine and four other cars. The matrix of 16 cars was pointed out, and the S was told that each of them was considered a different car, i.e., a red boxcar was different from a green boxcar.

The large notebook containing the items (trials) for the first concept attainment problem was pointed out to the S. He was then told, "In this book, one of these cars (E indicated matrix) is special. It is special because it will always be a part of one of the trains on each page. The other cars in the two trains may change, but one of the cars in one of the trains will always be the same--one car will always be in one of the trains, but not in the other."

Following this the three-page example was shown, and the train that contained the "special" car was pointed out.

The S was then told, "Try to figure out which train has the special car. Point to the train on each page that has the special car. Whatever the special car is, it will be the same for this whole book."

The S was informed that everytime he picked the special car, he would be given a colored chip, and that at the end of six problems he could trade in the chips that he had won for a prize. Some of the prizes (inexpensive toys, such as toy watches, jackstones, marbles, or felt marking pens) were on a shelf in the S's view. He was encouraged to see how many chips he could win.

After each of the problems a small portion of the instructions was repeated. (A complete version of the instructions is contained in the appendix.)

As indicated in the instructions, the S was required to point to the train which he thought contained the special car. The S was given a maximum of 15 seconds to respond on each trial or pair of items. At the end of 15 seconds he was urged to select one of the items, and then the page was turned for the next trial. If the S responded before 15

seconds had elapsed, E immediately turned the page to the next trial. If the response was correct, the E dropped a colored plastic chip into a container to the right of the S. The procedure was continued until S made 15 consecutive correct responses or completed the maximum of 60 trials for each problem. Each S was given all six problems in a random order.

Design and Analysis

A two-way multivariate analysis of variance allowing for two between groups factors (SES and age) and two within Ss factors (Problems and Blocks of Items) was used. Blocks of Items (six blocks of ten items), rather than Items, were used in the actual analysis of the data because of storage limitations of the Finn Multivariance Program on the Univac 1108.

The original 36 dependent measures (scores on 6 blocks of 10 for each of 6 problems) were transformed to generate contrast measures in three categories--(1) those expected to be large, (2) those expected to be small, and (3) those about which no predictions were made. The contrast measures resulting from the transformation are listed in Table 1.

Predictions could not be made about which component or function of the Problems X Items interaction expected to be large was most important. The difficulty with making more precise predictions was not knowing what point on the hypothetical learning curve was represented by 60 items. For example, 60 items might represent a point early on the learning curve where only linear components would be involved, as in Figure 4.

Table 1

Contrast Measures Generated from the 36 Original Variables

Those Expected to be Large	Those Expected to be Small	Those about which No Predictions were Made
1. Problems (linear) X Blocks (linear)	1. Problems (linear) X Blocks (quartic)	1. Problems (linear)
2. Problems (linear) X Blocks (quadratic)	2. Problems (linear) X Blocks (quintic)	2. Problems (quadratic)
3. Problems (linear) X Blocks (cubic)	3. Problems (quadratic) X Blocks (linear)	3. Problems (cubic)
	4. Problems (quadratic) X Blocks (quadratic)	4. Blocks (linear)
	5. Problems (quadratic) X Blocks (cubic)	5. Blocks (quadratic)
	6. Problems (quadratic) X Blocks (quartic)	6. Blocks (cubic)
	7. Problems (quadratic) X Blocks (quintic)	7. Blocks (quartic)
	8. Problems (cubic) X Blocks (linear)	8. Blocks (quintic)
	9. Problems (cubic) X Blocks (quadratic)	
	10. Problems (cubic) X Blocks (cubic)	
	11. Problems (cubic) X Blocks (quartic)	
	12. Problems (cubic) X Blocks (quintic)	

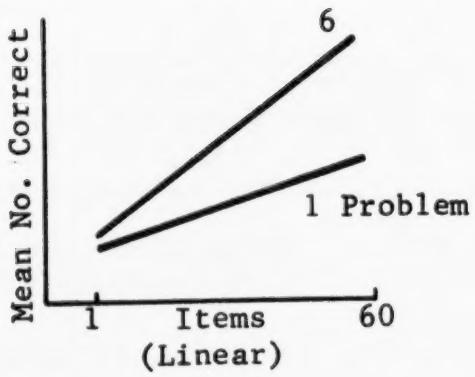

Fig. 4. Point on Hypothetical Learning Curve Represented by 60 Items. Problem by item interaction involves only a linear component for items.

Or, 60 items might represent points further along the learning curve where quadratic or cubic components would be involved, as in Figure 5.

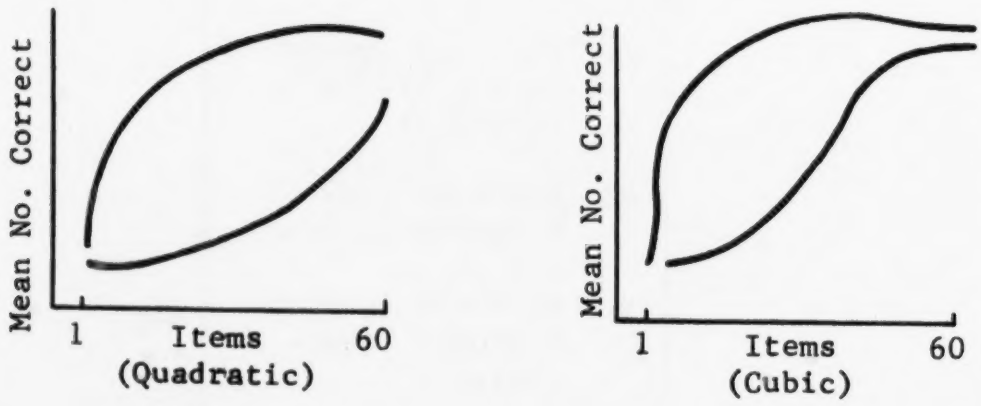

Fig. 5. Points on Hypothetical Learning Curves Represented by 60 Items. Problem by item interaction involves a quadratic component for items or a cubic component for items.

Any interaction of Problems by Items involving a linear component for problems and a linear, quadratic, or cubic component for items would be theoretically consistent with the ideas advanced here. All higher order components for problems (quadratic and cubic) and items (quartic and quintic) were expected to be an insignificant source of variation.

The predicted changes in the learning curves over problems for the six groups are summarized in Figure 6.

For four of the groups, there is no change in the relative shapes of the learning curves over problems. The most dramatic change occurs for the low SES 11-year-old group, with the 9-year-old, low SES group exhibiting a moderate degree of change.

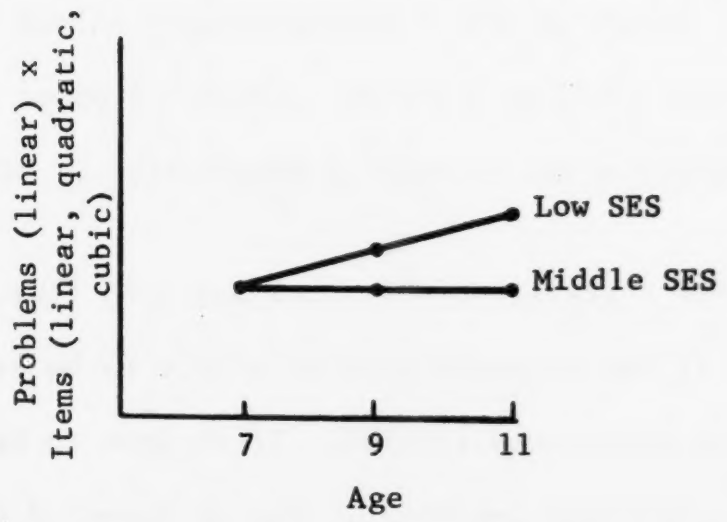

Fig. 6. Predicted Between Groups Differences in the Relative Amount of Change in the Shapes of the Learning Curves over Problems 1-6.

A set of five planned comparisons were used to test between groups differences. The first planned comparison, and the most important in terms of the predicted between group differences, examined the difference between the Low SES 9- and 11-year-old groups and the other four groups. The remaining four comparisons examined departures from the predicted between group differences. The second examined whether or not the Low SES 9-year-old group was half-way between the Low SES 11-year-old group and the remaining four groups. Comparisons three through five dealt with the question of whether or not the three Middle SES groups and the 7-year-old Low SES group were all the same.

Differences of interest were specified in terms of Δ, a ratio of mean difference to the within-cell standard deviation (Walster & Cleary, 1970). A power of .125 against a trivial difference of 1/8 σ and a power of .875 against an important difference of 3/4 σ was chosen. Sample size and the critical values of the F statistic were chosen in order to satisfy these criteria (Walster & Cleary, 1970). A power of .875 against the specified differences required a sample size of 108 observations.

The critical values of the F statistic were 2.42 and 2.45 (the Type I error rate was .09). If the observed statistic were to be less than 2.45, the effect would be considered trivial. If it were to be more than 2.42, it would be considered important. For an observed F statistic between 2.42 and 2.45, contradictory conclusions would be indicated, i.e., the effect is both large and small. In this case judgment would be suspended.

IV

RESULTS AND DISCUSSION

The results of the analysis of variance are summarized in Table 2. The multivariate test for the planned comparison between the low SES, 9- and 11-year-old groups versus the other four groups for the three dependent variables of expected to be large, (1) Problems (linear) X Blocks (linear), (2) Problems (linear) X Blocks (quadratic), (3) Problems (linear) X Blocks (cubic), resulted in an $\underline{F}$ = 1.80. Contrary to prediction, this difference was clearly trivial.

Table 2

Multivariate Analysis of Variance for Five Planned Comparisons and Two Sets of Dependent Variables (Those Expected to be Large and Those Expected to be Small)

	df	F
1st Planned Comparison		
(Low SES 9- + 11-year-olds vs. Low SES 7-year-olds + Middle SES 7-, 9-, and 11-year olds)		
Problems (linear) X Blocks (linear, quadratic, cubic)	1	1.80
Problems (linear) X Blocks (quartic, quintic); Problems (quadratic) X Blocks (linear, quadratic, cubic, quartic, quintic); Problems (cubic) X Blocks (linear, quadratic, cubic, quartic, quintic)	1	1.06

Table 2 (cont.)

	df	F
2nd, 3rd, 4th, and 5th Planned Comparisons		
(Low SES 9-year-olds vs. all others)		
(Low SES 7-year-olds + Middle SES 9- and 11-year-olds vs. Middle SES 7-year-olds)		
(Low SES 7-year-olds + Middle SES 11-year-olds vs. Middle SES 9-year-olds)		
(Low SES 7-year-olds vs. Middle SES 11-year-olds)		
Problems (linear) X Blocks (linear, quadratic, cubic)	4	1.50
Problems (linear) X Blocks (quartic, quintic); Problems (quadratic) X Blocks (linear, quadratic, cubic, quartic, quintic); Problems (cubic) X Blocks (linear, quadratic, cubic, quartic, quintic)	4	1.02

A joint test of the null hypotheses for the four remaining planned comparisons for the three dependent variables expected to be large resulted in an $\underline{F} = 1.50$. This joint test was insignificant, as predicted.

The interactions of the higher order components for Problems (quadratic and cubic) and Blocks of Items (quartic and quintic) were insignificant sources of variation for all comparisons. The F statistic for the first planned comparison was 1.06 and for the joint test of the remaining four comparisons, 1.02.

Since the learning curves over problems 1-6 as measured by linear, quadratic, and cubic components for problems and linear, quadratic,

cubic, quartic, and quintic components for items were not significantly different for any of the six groups, the number correct for Blocks of Items for each of the six problems were averaged for all groups. The average number of items correct for Blocks of Items for Problems 1 and 6 are shown in Figure 7. Although there is some gain from Problems 1 to 6, there is minimal gain over Blocks of Items within a single problem.

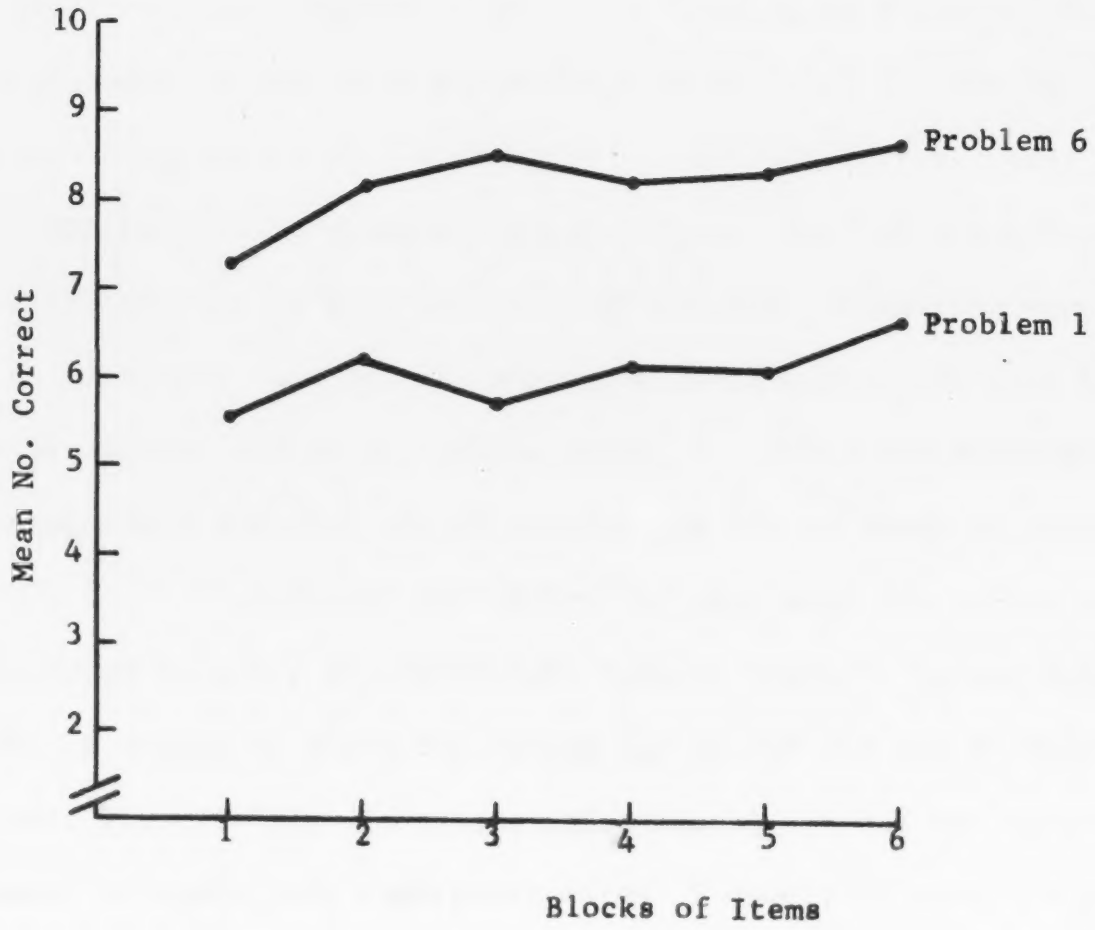

Fig. 7. Average number of items correct for all SES X Age groups for Problems 1 and 6.

The results of this study fail to confirm the proposed changes in the shapes of the learning curves from Problems 1 to 6 for the 11-year-old, low SES group. The learning curves change in a uniform manner from Problems 1 to 6 for low SES and middle SES children at the three ages studied.

SES group differences with children as old as 11 years thus cannot be explained in terms of relatively small differences in how much they have learned about how to go about learning a concept attainment task. By "relatively small," it is meant differences that can be compensated for during less than one hour in the laboratory. It is possible that age 11 is too young to have expected the performance of the two SES groups to have converged. The low SES children at this age may still be handicapped by a relatively large developmental lag with regard to concept attainment abilities. In other words, LTL in the laboratory was not sufficient to speed up the acquisition of the relevant developmental experiences needed for this task by 11-year-old children.

The mean number of items correct over Blocks of Items on Problems 1 and 6 for each of the six SES by age groups are shown in Figure 8. The learning curves for the six groups taken separately are all very similar to the single curves in Figure 7, which represents the number of items correct over Blocks of Items for all of the six groups averaged together. In general, for a single problem, there is a small increase in the mean number of items correct over Blocks of Items, but a much larger increase from Problem 1 to Problem 6.

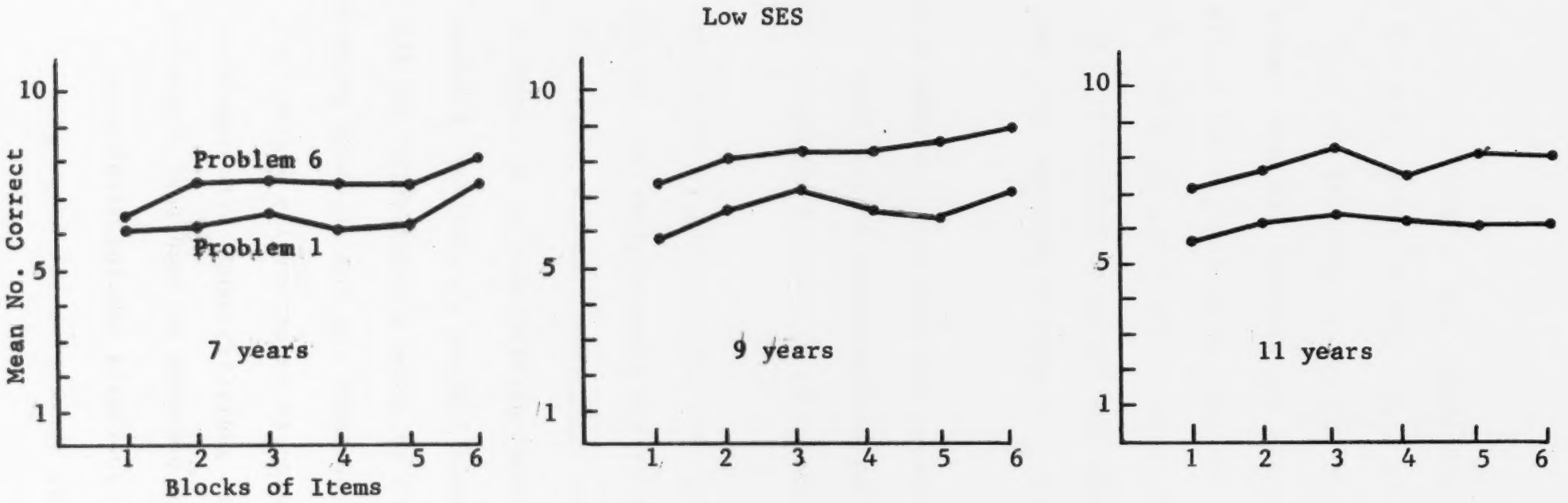

Fig. 8. Mean Number of Items Correct over Blocks of Items on Problems 1 and 6 for the Six SES by age Groups.

On the basis of a visual inspection alone, the largest increase from Problem 1 to Problem 6 was for the middle SES 9- and 11-year-old groups. This relatively large increase appears in spite of the fact that there was a ceiling effect for these two groups. The mean number of items correct for the middle SES, 11-year-old group for the six Blocks of Items on Problem 6 were 8.67, 9.39, 9.78, 9.89, 9.72, and 9.94. For the 9-year-old group, the means for the six Blocks on Problem 6 were 8.06, 9.33, 9.56, 9.61, 9.72, and 9.67. It appears that the task was too easy for these Ss.

For future use with Ss such as these, the task could be made more difficult by including additional stimulus dimensions as relevant attributes, so that the concept included three or more dimensions rather than merely two.

Since the Ss in the present study were not required to verbalize their hypotheses for each problem, it is not known whether the low SES children formulated different kinds of hypotheses from the middle SES children, preferred different dimensions, perseverated on different dimensions, or used different hypothesis testing strategies. Studies which attempt to answer questions such as these are suggested for the future. The task used here would be suitable for any of these purposes.

The LTL paradigm is still advocated as an especially appropriate one within which to examine these more analytic issues with regard to concept attainment. The LTL paradigm provides an important dimension on which to study such behaviors as hypothesis testing strategies, namely, changes in such behaviors over successive but comparable problems.

APPENDIX

Instructions to Subjects

INSTRUCTIONS

(Have example sheet/sheets and car matrix on display when student enters.)

I am going to show some pictures of trains. (Point to example page.) All of the pictures in this book (indicate the first book) will have two trains on each page, like this (point to example page).

Every train has an engine (point to) and four other cars. The four cars that make up the train may be any of these (indicate matrix). There are four types of cars--(point to them) boxcars, coal cars, tankers, and cabooses. Each of them comes in four different colors (point to)--yellow, blue, green, and red. Each of these (indicate matrix) is considered a different car--for example, a red boxcar is different from a green boxcar.

In this book (indicate first book), one of these cars (indicate matrix) is special. It is special because it will always be a part of the trains on each page. The other cars in the two trains may change, but one of the cars in one of the trains will always be the same--one car will always be in one of the trains, but not in the other.

The engine or locomotive doesn't count. Smudgey ink or crooked cars don't count. Remember the special car will always be one of these (point to matrix).

(EXAMPLE) Here is an example. (Point to top train.) This train has the special car. The special car is a green tanker. (Turn page.) (Point to bottom train.) This train has the special car. The special car is a green tanker. (Turn page.) (Point to bottom train.) This

train has the special car. The special car is a green tanker.

Try to figure out which train has the special car. Point to the train on each page that has the special car. Whatever the special car is, it will be the same for this whole book.

Every time you pick the train with the special car, I will give you a chip. When I give you a chip that means that you picked the train with the special car--that will be your signal that you picked the train with the special car. If I don't give you a chip, that means that you did <u>not</u> pick the train with the special car. At the end of the six problems, you can trade in the chips you have won for a prize. See how many chips you can win.

1. (Remove example sheet and car matrix)
2. (Place book in position)

Try to figure out which train has the special car. Point to the train that has the special car. At first you'll have to guess, but as you go along, you should be able to figure out what the special car is.

3. (Open book and begin)
4. (As soon as the student makes his choice, go on to the next page. Do not allow them to study one page for longer than 12 seconds--force them to make a choice and go on to the next page.)
5. (Continue to go through the book until the student has given <u>15 consecutive</u> correct responses or until you reach the end of the book.)

(REPEAT AT THE BEGINNING OF EACH PROBLEM)

The special car for this book is different, but otherwise the pictures are the same. Remember, one of these cars is special (show matrix). It is special because on each page it will always be a part of one of the trains, but not of the other. Whatever the special car is, it will be the same for this whole book. See if you can win more chips this time.

REFERENCES

Adams, J. A. Multiple versus single problem training in human problem solving. Journal of Experimental Psychology, 1954, 48, 15-18.

Ahlers, S. M. The formation of learning sets on three discrimination problems by 5- to 6-year-olds. Dissertation Abstracts, 1968, 29 (1-B), 383.

Anderson, R. C., & Gutherie, J. T. Effects of some sequential manipulations of relevant and irrelevant stimulus dimensions on concept learning. Journal of Experimental Psychology, 1966, 72, 501-504.

Byers, J. L. Strategies and learning set in concept attainment. Psychological Reports, 1963, 12, 623-634.

Bowes, A. E. Problem difficulty as a factor in learning set formation by children. Dissertation Abstracts, 1963, 23, (12, Pt. 1), 4752.

Callentine, M. F., & Warren, J. M. Learning sets in human concept formation. Psychological Reports, 1955, 1, 363-367.

Crooks, J. L. The effect of overtraining on learning set formation in children. Dissertation Abstracts, 1967, 27 (9-B), 3304-3305.

Deese, J., & Hulse, S. H. The Psychology of Learning. New York: McGraw-Hill, 1967.

Detambel, M. H., & Stolurow, L. M. Stimulus sequence and concept learning. Journal of Experimental Psychology, 1956, 51, 34-40.

DiVesta, F. J., & Walls, R. T. Multiple- versus single-problem training and variations of solution rules in the formation of learning sets. Journal of Educational Psychology, 1968, 59, 191-196.

Duncan, C. P. Description of learning to learn in human subjects. American Journal of Psychology, 1960, 73, 108-114.

Ellis, N. R., Girardeau, F. L., & Pryer, M. W. Analysis of learning sets in normal and severely defective humans. Journal of Comparative and Physiological Psychology, 1962, 55, 860-865.

Girardeau, F. L. The formation of discrimination learning sets in mongaloid and normal children. Journal of Comparative and Physiological Psychology, 1959, 52, 566-670.

Glanzer, M., Huttenlocher, J., & Clark, W. H. Systematic operations in solving concept problems: A parametric study of a class of problems. Psychological Monographs, 1963, 77, Whole No. 564.

Goulet, L. R. Verbal learning in children: Implications for developmental research. Psychological Bulletin, 1968, 69, 359-376.

Harlow, H. F. The formation of learning sets. Psychological Review, 1949, 56, 51-65.

Harlow, H. F. Learning set and error factor theory. In Sigmund Koch (Ed.), Psychology: A Study of a Science, Vol. 2. New York: McGraw-Hill, 1959, 492-537.

Harter, S. Discrimination learning set in children as a function of IQ and MA. Journal of Experimental Child Psychology, 1965, 2, 31-43.

Jensen, A. R. Varieties of individual differences in learning. In R. M. Gagne (Ed.), Learning and Individual Differences. Columbus, Ohio: Charles E. Merrill, 1967.

Kaufman, M. E., & Peterson, W. M. Acquisition of learning set by normal and mentally retarded children. Journal of Comparative and Physiological Psychology, 1958, 51, 619-621.

Katz, P. A. Acquisition and retention of discrimination learning sets in lower-class preschool children. Journal of Educational Psychology, 1967, 58, 253-258.

Keppel, G. Verbal learning in children. Psychological Bulletin, 1964, 61, 63-80.

Kintz, B. L., Foster, M. S., Hart, J. O., O'Malley, J. J., Palmer, E. L., & Sullivan, S. L. A comparison of learning sets in humans, primates, and subprimates. General Psychology, 1969, 80, 189-204.

Koch, M. B., & Meyer, D. R. A relationship of mental age to learning-set formation in the preschool child. Journal of Comparative and Physiological Psychology, 1959, 52, 387-389.

Levinson, B., & Reese, H. W. Patterns of discrimination learning set in preschool children, fifth-graders, college freshmen, and the aged. Monograph of the Society for Research in Child Development, 1967, 32, No. 7.

McGeoch, J. A., & Irion, A. L. The Psychology of Human Learning. New York: McKay, 1952.

Meyer, D. R., & Miles, R. C. Intralist-interlist relations in verbal learning. Journal of Experimental Psychology, 1953, 45, 109-115.

Monge, R. H. Adult age differences in paired-associate verbal learning set formation. Dissertation Abstracts, 1968, 28, (11-B), 4748-4749.

Odom, R. D. Problem-solving strategies as a function of age and socio-economic level. Child Development, 1967, 38, 747-752.

Osler, S. F., & Fivel, M. W. Concept attainment I: The role of age and intelligence in concept attainment by induction. Journal of Experimental Psychology, 1961, 62, 1-8.

Peterson, M. J. Concept identification as a function of the type of training series. Journal of Experimental Psychology, 1968, 78, 128-136.

Postman, L. Studies of learning to learn: VI. General transfer effects in three-stage mediation. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 659-664.

Postman, L., & Schwartz, M. Studies of learning to learn. I. Transfer as a function of method of practice and class of verbal materials. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 37-49.

Rohwer, W. D. Mental elaboration and proficient learning. Unpublished manuscript, University of California, Berkeley, California, 1969.

Rohwer, W. D., Jr., Ammon, M. S., Suzuki, N., & Levin, J. R. Ethnicity-SES and learning proficiency. Unpublished manuscript, University of California, Berkeley, California, 1969.

Rohwer, W. D., Jr., Suzuki, N., & Ehri, L. Socioeconomic status and learning proficiency in young children. Paper presented at the annual meeting of the American Educational Research Association, Chicago, 1968.

Saravo, A., & Gollin, E. S. Oddity learning and learning sets in children. Journal of Experimental Child Psychology, 1969, 7, 341-352.

Semler, I. J., & Iscoe, I. Comparative and developmental study of learning abilities of Negro and white children under four conditions. Journal of Educational Psychology, 1963, 54, 38-44.

Sheppard, W. C. Learning set in preschool children. Journal of Comparative and Physiological Psychology, 1957, 50, 13-17.

Stevenson, H. W., & Swartz, J. D. Learning set in children as a function of intellectual level. Journal of Comparative and Physiological Psychology, 1958, 51, 755-757.

Underwood, B. J. Experimental Psychology. New York: Appleton-Century-Crofts, 1966.

Walster, G. W. Personal communication, 1970.

Walster, G. W., & Cleary, T. A. The use of statistical significance as a decision rule. The American Statistician, 1970, 24, 16-19.

Weber, R., & Woodward, A., Jr. Positive and negative information in learning set. Journal of Experimental Psychology, 1966, 72, 492-496.

Wischner, G. J., & O'Donnell, J. P. Concurrent learning set formation in normal and retarded children. Journal of Comparative and Physiological Psychology, 1962, 55, 524-527.